In the Nation's Best Interest: Making the Most of NOAA's Science Enterprise

A Draft Report to the NOAA Science Advisory Board

by

The R & D Portfolio Review

Task Force

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Executive Summary

NOAA conducts world class research and development (R&D) that is critical to the nation's security, economic growth, and environmental health. Its importance will expand in the future as coastal and ocean resources and weather and climate information become even more strategically important to the economy, and American lives, property, and critical infrastructure are increasingly exposed to coastal flooding and extreme weather. NOAA now requires an R&D portfolio that is more sharply focused on key areas essential to improving its services to the nation. Given today's fiscal realities, NOAA can meet its mandate only if it significantly changes the management of its R&D portfolio and is given the flexibility to allocate its R&D budget to its highest priorities, as specified in the Next Generation Strategic Plan. NOAA's capability to set R&D priorities and to focus research on those priority areas must be strengthened. To accomplish this, the Task Force finds it imperative that NOAA implement fundamental scientific, structural, and budgetary changes, including the following highest priority recommendations:

1) Replace the current Chief Scientist position with a Deputy Under Secretary of Commerce for R&D who has responsibility for research across the agency and has the necessary budget authority to direct all NOAA research. The establishment of this position will provide the incumbent with authority to align NOAA's resources for research with its strategic priorities across the agency.

2) Maintain a strong core of internal scientists whose skill sets fit with the agency's current and anticipated strategic priorities and are necessary to support NOAA's mission.

3) Increase the agency's scientific breadth and flexibility by leveraging the contributions of partners in the academic, public, and private sectors. NOAA should expand its extramural research investments with funding obtained by reducing its intramural research investments.

4) Develop a strong research capability, internally and externally, in the socioeconomic and integrated ecosystem sciences, and ensure the nation's science needs are met by NOAA's observation and data sharing systems.

5) Obtain budget flexibility to fund these changes by eliminating or consolidating duplicative R&D and research unrelated to its strategic priorities and by working more closely with the Congress, the Office of Management and Budget, and the Department of Commerce on transitioning from the current organizational structure to one that is better able to provide NOAA with the R&D portfolio and the flexibility it needs under the Next Generation Strategic Plan.

Further details are contained in the body of this report.

Introduction: The Case for Science at NOAA

The National Oceanographic and Atmospheric Administration (NOAA) conducts a broad range of research and development (R&D) and through this provides information and services critical to the economic and physical security of the nation. Scientific research informs every aspect of NOAA's work, providing a strong foundation for forecasting the approach of the next hurricane or winter storm, issuing warnings of on-coming solar storms, aiding coastal communities in obtaining livelihoods while keeping safe from the worst consequences of hurricanes and flooding and providing information that enables both public and private sectors to make wise decisions regarding the stewardship of our increasingly valuable ocean resources.

NOAA's activities demand a deep scientific understanding of ocean, atmospheric, and terrestrial processes and their implications and rely on sophisticated tools for monitoring, analysis, and prediction of these processes. Both the scientific understanding and the tools are based on research carried out in NOAA, in the nation's universities, and in commercial firms and non-governmental organizations. NOAA scientists not only study the Earth's ocean and atmosphere, but also how physical processes affect coastal communities and infrastructure. They transform new and prior knowledge to resolve real world problems.

NOAA collaborates with leading university scientists through its Cooperative Institutes, programs such as Sea Grant, and extramural grants programs. Through its laboratories and centers, the agency applies advanced research findings to develop new tools for monitoring the atmosphere, the oceans, and ocean resources, and forecasting both extreme environmental events and the impacts of those events in an increasingly environmentally dependent and information-centric society.

The agency also provides critical national data infrastructure that allows scientists everywhere to monitor the continuous evolution of conditions in the ocean, weather, coasts, and atmosphere and makes all its data (including model output) freely available for scientific, educational, commercial, and other purposes. This information infrastructure provides a foundation for informed decision making in the public and private sectors, nationally and locally and supports a vibrant private sector in operational meteorology.

NOAA's contribution to federal R&D is related to its role as a service arm of the government. Unlike the National Science Foundation (NSF), which is responsible for basic scientific research or the National Aeronautics and Space Administration (NASA), which is responsible for space exploration and technological innovation, NOAA balances use-inspired research with exploratory scientific research related to its mission. NOAA's mandate is to ensure that its R&D is focused on obtaining new knowledge related to questions of immediate relevance to the nation's needs for a safe public and productive economy.

NOAA research has had and continues to have numerous successes in addressing real world problems. One example is the identification of the cause of the so-called "ozone hole" over the Antarctic. NOAA researchers, working in close partnership with university and other agency colleagues, were the first to correctly explain the complex photochemistry and unique circumstances present in the

Austral winter high over the Antarctic and connect the cause to manmade chemicals. This new knowledge directly influenced the formulation of national and international policy, leading to the Montreal Protocol in 1987 that phased out the emission of manmade ozone depleting gases. NOAA scientists have carried out use-inspired research to improve radar technology for detection of tornadoes, large hail, and extreme winds. This technology is now deployed in weather surveillance radars. Further, in the last few years, scientists have also developed a new technology involving dual-polarization of the radar beam and exploited the newly available information to make fundamental advances in determination of precipitation type and amount. Once it is retrofitted into the national radar network, it will allow greatly improved detection and forecasting of severe weather, winter weather, and flash flooding. Of urgent emerging importance is NOAA's ongoing research aimed at better understanding and predicting the impacts of ocean acidification on ocean resources, and the implications of reduced Arctic ice for shipping, fisheries, and the global climate.

Although its scientific research enables NOAA to make significant contributions to the nation and the economy, the agency's annual R&D budget is surprisingly small, especially when compared to that of other federal science agencies with parallel missions. For example, NOAA's research budget is approximately 2% of the research budget of the National Institutes of Health (NIH). The comparison is telling because arguably the two agencies have missions of equivalent importance to the nation, and the use-inspired missions of the two agencies are quite similar. That is, the NIH is responsible for the nation's physical health and well-being, NOAA is responsible for maintaining the health and well-being of the nation's coasts, harbors, and coastal communities; its weather forecasting and warning systems for hurricanes, tornados, rainfall, tsunamis, and other extreme weather events throughout the country; and its fisheries and ocean resources. The number of US residents whose jobs, property, and financial well-being is affected by NOAA's activities is on the same scale as the number affected by NIH's activities.

NOAA R&D Portfolio Review Task Force

At the request of NOAA Administrator Dr. Jane Lubchenco, the Science Advisory Board (SAB) undertook in 2012 a review of the agency's research and development portfolio. The shared goal of the SAB and the Administrator was to ensure that NOAA's investment in R&D contributes to the economic, employment, national security, nutritional, life and property benefits to the United States.

In response to Dr. Lubchenco's request, the Science Advisory Board appointed the R&D Portfolio Review Task Force (PRTF) and charged it with determining how NOAA's R&D portfolio is related to its strategic mission priorities, and based on this assessment, advising how the R&D enterprise should be structured and managed at NOAA. More specifically, the Task Force was directed to examine how the current state of research at NOAA supported the strategic goals in the agency's Next Generation Strategic Plan and with recommending management changes where necessary to ensure alignment with those goals.

The SAB launched this review because it anticipates that discussions on prioritizing R&D are necessary across all federal agencies over the next several years. Thus, an overall goal of the review was to ensure that current and future investments in R&D at NOAA are and will be spent effectively and productively in support of the top priorities of the agency. An operating assumption of this effort was that there would be no new funding for R&D in the immediate future.

The terms of reference for the review set out two major questions for the PRTF to address:

1. What portfolio of R&D activities does NOAA need to achieve its vision and strategic goals?

2. How should NOAA's R&D portfolio be organized and managed to achieve its vision and strategic goals?

In conveying this charge to the Task Force, the SAB emphasized that a successful review of NOAA's R&D portfolio would be one that provides recommendations that were actionable and which could be understood by NOAA staff and leadership, the Department of Commerce, the Office of Management and Budget, and Members of Congress and their staffs. For a copy of the full Terms of Reference, see Appendix I.

The disciplinary and research backgrounds of members of the Task Force spanned the scientific disciplines related to NOAA's mission. Because of the importance of this group's work, roughly half its members were also members of the Science Advisory Board and half were individuals from outside the Board. Members were selected from the private sector, universities, state government, and the not-for-profit sector. For a list of the Task Force members, see Appendix II.

The Science Advisory Board placed the work of the Task Force on a fast track, asking it to provide a preliminary report at the November 2012 meeting of the SAB, eight months after its first meeting. In this timeframe, the task Force could not set detailed priorities for research throughout NOAA. Rather, we highlight where we see areas that need to be strengthened in order to follow through on the Next Generation Strategic Plan and how to organize the agency's R&D activities to ensure that scientific priorities can be responsive to the strategic plan, and to emerging national needs.

The primary sources of information available to the Task Force consisted of strategic and research planning documents, and research reports and summaries. The Task Force requested, and received, budget figures on R&D expenditures. It also conducted extensive interviews with NOAA leadership (past and present), the agency's research managers and scientists (both individually and in groups), and NOAA grantees. Interviews were also held with scientists at NOAA's Cooperative Institutes and other centers, and with academic scientists working outside NOAA. In addition, there was an anonymous Internet survey of bench scientists at NOAA. A list of information resources available to the Task Force is shown in Appendix VIII and a list of groups interviewed or providing comments for this study is shown in Appendix IV. A list of meetings and conference calls of the PRTF can be found in Appendix III.

The Task Force was assisted in obtaining these information resources by an extremely able and efficient team of NOAA employees led by Steven Fine of NOAA's Program Planning and Integration Directorate. See Appendix VIII for a full list of NOAA personnel who assisted the Task Force in its work.

NOAA Research Enterprise Baselines

Budget

As figure 1 shows for the past five years, NOAA's R&D budget peaked in FY 2009 at $608M for R&D, with an additional $347M for R&D equipment. Since then, the R&D budget has been in decline. The estimates for FY 2012 are $443M for R&D and $137M for R&D equipment.

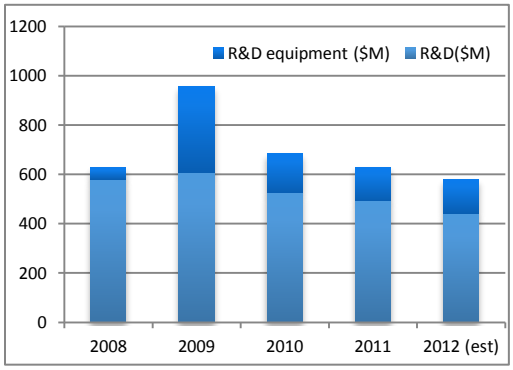

Figure 1. NOAA's R&D budget, including equipment.

Figure 2 shows the change in federal research budgets between 2010 and 2012. Figure 3 shows the change in NOAA's R&D allocation. During this period, NOAA's Office of Oceanic and Atmospheric Research (OAR), the office supporting and conducting most of NOAA's R&D, experienced a significant absolute reduction in funding. Over the same period R&D efforts within NOAA's National Weather Service (NWS) experienced the largest proportional reductions in the NOAA research enterprise.

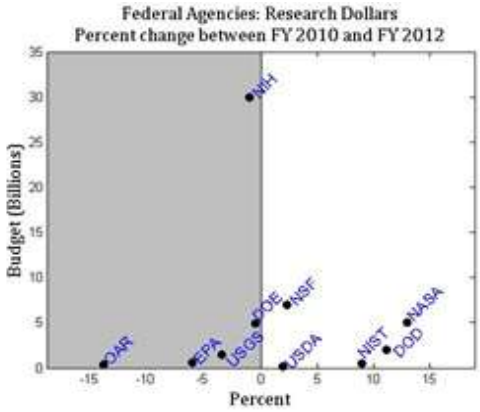

Figure 2. Percent change in federal agency research dollars between FY2010 and FY2012.

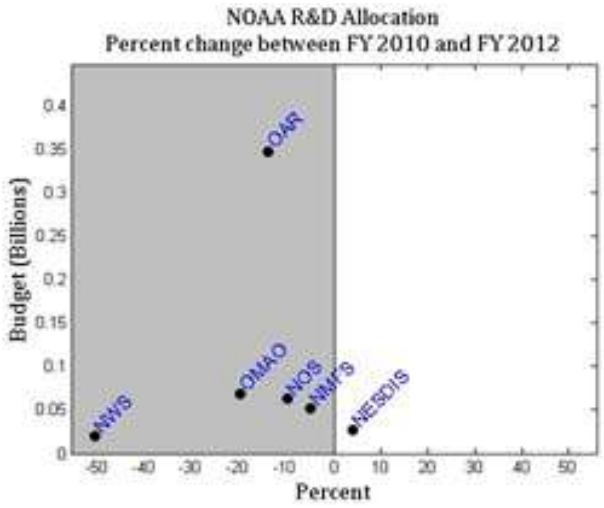

Figure 3. NOAA R&D allocation examined as percent change between FY2010 and FY2012.

Partnerships

NOAA partners include a number of extramural long-term, institutional relationships. The largest set of these is the NOAA Cooperative Institutes (CIs), which are academic and non-profit research institutions that support NOAA's Mission Goals and Strategic Plan via long-term (5-10 year) formal collaborations with the agency. Currently, NOAA supports 18 Cooperative Institutes made up of 48 universities and research institutions across 21 states, Puerto Rico and the US Virgin Islands. In FY 2011, NOAA provided $176M to the Cooperative Institutes, which supported 1,211 employees and 485 students. Other examples of long-term partners include Sea Grant programs and National Estuarine Research Reserves.

NOAA awards shorter-term grants to a number of research institutions. Recent research grants have addressed aviation weather, ecosystem predictions, protected species, aquaculture, ocean exploration, and climate modeling. More than $110M was provided for extramural grants in FY 2011.

People

NOAA's R&D internal expertise is primarily concentrated in the biological and physical sciences. However, NOAA also employs scientists and engineers from a broader range of disciplines—including economics, computer science, geospatial technologies, and electrical engineering.

Table 1, below, shows the number of "bench scientists" at NOAA facilities within the major, NOAA-relevant occupational groups of the federal job series. (Note: these numbers were provided by the managers of each research unit, who judged which people fit the functional definition of bench scientists, *i.e.,* were "expected or encouraged to publish" or whose positions were integral to scientific and technical activities. The exception to this was the National Marine Fisheries Service (NMFS), which based its estimates of bench scientists on job series and grade, and therefore probably overestimated the number of bench scientists compared with other line offices.)

Specialization	Number of People
Natural Resources Management and Biological Sciences	1296
Physical Sciences	1063
Mathematics and Statistics	128
Engineering and Architecture	80
Social Science, Psychology, and Welfare	67
Information Technology	16
Other	70
Total	**2720**

Of these "bench scientists," 63% are Federal employees, 17% work for universities or other non-profit organizations, and 14% are contractors. The remainder are post-doctoral fellows and students.

NOAA has an aging workforce, as do many Federal agencies. Many employees engaged in R&D are eligible to retire now, and many more will become eligible in the next three years. Within the job categories and organizations that contain the majority of the "bench scientists," approximately 19% of the people are eligible to retire now, and 30% will be eligible in 2016. Job series that have higher than average retirement eligibility include physics, meteorology, oceanography, computer science, and chemistry.

Research Priorities for NOAA's Next Generation Strategic Plan

In its Next Generation Strategic Plan (NGSP), NOAA has put in place a means of focusing its work on major national needs in the areas of weather, climate, oceans and coastal communities and economies (a summary of the NGSP is in Appendix V). By asking the Task Force to consider R&D priorities based on this plan, the agency has committed itself to ensuring that it is capable of fulfilling its mission. The Task Force commends NOAA both for developing the strategic plan and for affirming NOAA's commitment to science, service, and stewardship and its ongoing role as a central force in the protection of life and property in the United States.

The four strategic themes from the Next Generation Strategic Plan are:

- **Healthy Oceans**: Ensuring healthy oceans for future generations will require three major research innovations: 1) development of cost-effective ecosystem monitoring and observing tools and data management systems; 2) pragmatic application of ecosystem science to improve forecasting at the relevant spatial and temporal scales such that management decisions can maximize attainment of multiple societal goals (food, energy, transportation, safety, *etc.*); and 3) much improved socioeconomic analyses of the tradeoffs inherent in ecosystem-based management so that difficult resource decisions are accepted as fair, and bureaucratic processes are minimized.

- **Weather Ready Nation:** Preparing the nation for extreme weather is essential to protecting lives and livelihoods. Emerging research initiatives that meet this need are: 1) maximization of the multiple streams of data and information available, and the integration of those streams to anticipate extreme weather events; 2) development of better ways of assessing and communicating risk so that both the public and decision-makers have the information they need to react appropriately when faced with oncoming extreme events; and 3) significant enhancement of our understanding of long term weather trends and extreme weather profiles.

- **Climate Adaptation and Mitigation**: Private sector business planning, as well as government planning at the local, state, and national levels, requires a basic understanding of climate trends. For instance, are droughts increasing in frequency and severity; what are the trends for winter storms; and what are the likely socioeconomic impacts? Public and private decision makers also require science-based guidance on how to adapt to and mitigate the undesirable impacts. This level of understanding will require important research innovations: 1) development and application of climate models at more relevant spatial scales than the current generation of global models, with easily interpreted representations of uncertainty; 2) improvement of the linkages between climate science, resilient communities and businesses, and a weather ready-nation, and 3) integration of data and models in a manner that supports decision-making without requiring extensive technical background.

- **Resilient Coastal Communities and Economies:** With over half of the US population living within coastal watershed counties of the United States, including the Great Lakes, there is an obvious need for enhancing the resiliency and economic vitality in these communities. The research advances needed to do this fall into three main categories: 1) better understanding of the weather-related and oceanic risks faced by coastal communities; 2) integration of assessments of natural habitat change with planning for smart growth and human/coastal engineering to minimize risks to humans, property, and the environment; and 3) development of sophisticated, but simple to use decision support tools to ensure the greatest economic, social, and ecological return on investments in restoration or engineering solutions aimed at maintaining resilience and productivity.

Taken as a whole, these four themes provide the context for the environmental information that will be critical to the well-being of the United States in the decades ahead. Increased frequency of high impact weather, droughts, floods and wild fires, along with rising sea levels and ocean acidification will affect almost every aspect of the nation's economy, environment, and society. Dealing with these impacts will require deeper understanding not only of the physical, chemical, and radiation processes that drive the climate system (atmosphere, oceans, land, biosphere and cryosphere), but also of the increasingly significant ecological and socioeconomic processes that interact with these. NOAA science, critical to our nation today, will be even more critical in the future.

The Task Force finds that execution of the NGSP will require NOAA to cultivate different types of research than it has in the past. Specifically, ***(Recommendation 1) NOAA needs to develop a strong capacity in the socioeconomic and integrated ecosystem sciences and to reinforce its emphasis on operations and integrated observing systems so that new knowledge can be rapidly used to benefit the nation.*** We take up these needs in detail below.

Recommendations for New Research Capacities in the Socioeconomic and Ecosystem Sciences

Socioeconomic Sciences

Throughout the NGSP, there is an emphasis on fostering economically strong communities and understanding weather and climate impacts on societies, economies, and governance. It also emphasizes the need to provide information for management and decision making in the public and private sectors in regard to weather, ocean, coasts, and climate. A few examples of strategic areas highlighted by the Next Generation Strategic Plan that are based on socioeconomic research are given in the chart in Appendix VII. Meeting NOAA's strategic goals requires that the agency expand its research capacity in economics, geography, decision science, psychology, sociology, anthropology, and other relevant fields in the socioeconomic sciences. This need has been identified and discussed at length in several reports of the NOAA Science Advisory Board over the past decade, but the recommendations of these reports have generally been ignored. A more complete discussion of the earlier SAB reports on the social sciences and the NOAA responses to those reports can be found in Appendix VII.

Therefore, the Task Force now recommends that the organization of R&D at NOAA be changed to expand NOAA's R&D capacity in this increasingly important area of science. ***(Recommendation 2) Funding needs to be reallocated from support for R&D in other fields of science at NOAA in order to build both an in-house capacity in the socioeconomic sciences and extramural capacity in these fields.***

Ecosystem Sciences

One of the priorities for NOAA identified by the National Ocean Policy is to implement an ecosystem approach to management and coastal and marine spatial planning. This new approach is needed if NOAA is to fulfill its mission of protecting people, property and the environment while simultaneously meeting society's needs for commerce and ocean resources. Currently NOAA lacks both the staffing and the organizational structure to meet this research need and is consequently hampered in its efforts to create effective tools and procedures for rapid advances in ecosystem management. Currently, NOAA's lacks a sufficient number of ecosystem specialists, and those it has are spread among NOS, NMFS, NESDIS, and OAR. As a consequence, the agency is not adequately resourced or organized to deliver the ecosystem science the nation needs. NOAA also misses opportunities for leveraging ongoing ecosystem science research in EPA and USGS.

(Recommendation 3) NOAA needs to enhance and concentrate its ecosystem science activities to establish the critical research capacity it needs in integrated ecosystem sciences.

The nation's ocean and coastal areas are increasingly subject to competing user demands, such as recreation, shipping, fisheries, mineral and fossil fuel extraction, wind farms, wave farms, and aquaculture. Wise co-development of the ocean's many resources can only be accomplished with a solid foundation of ecosystem science that links together the impacts of all these activities on the functioning of our coastal areas and ocean, as opposed to the piecemeal, "one resource-at-a-time approach" that represents current practice. Experimental tests of ecosystem approaches go unfunded while valuable resources are deployed on single-species stock assessments. Yet it is not clear that improvements in stock assessment will yield dramatic improvements in the performance of fisheries, whereas large returns from an ecosystem approach are highly likely.

Strengthening Research to Operations/Operations to Research (R2O/O2R)

NOAA is a mission organization. The three pillars of the organization are science, service and stewardship. Its work begins with science, but unless that science is transitioned into operations--whether in services to the nation or stewardship of the nation's resources--NOAA will fail in its mission. NOAA must make certain that the end use of the scientific information is understood from the start by its researchers working on scientific questions and in particular to ensure that internal as well as external end-user needs are incorporated explicitly into the problem formulation. In light of the importance of R2O/O2R, the PRTF recommends the following:

(Recommendation 4) In both the Research to Operations (R2O) and Operations to Research (O2R) processes, NOAA must place greater emphasis on connecting research and operations.

(Recommendation 5) One of the most effective ways of enhancing the transitioning of research into operations/applications is to forge new partnerships of researchers and end-users at the outset of a project, and to continue these partnerships until the project is complete. This also applies to partnerships among NOAA personnel and university and NGO researchers through extramural programs.

(Recommendation 6) Effectiveness in transitioning research to operations should be an explicit metric in annual performance evaluations of all NOAA scientists, laboratory and center administrators, and other relevant personnel.

Maintaining Critical Observing Strategies

One of the ongoing activities at NOAA that is integral to the infrastructure of the nation's science enterprise and its economic viability is NOAA's work on Earth observations. The agency's observing systems include platforms such as ships and satellites, sensors, data networks, and cutting edge informatics. There is, however, room for improvement—both in effectiveness and cost-efficiency.

As an example, given the need to protect and sustain resilient coastal communities, the absence of an integrated coastal observation system is a matter of particular concern. Addressing this need will require investment in informatics, data systems, and Earth system science as much as in the

observation platforms themselves. It is obvious that oceanic processes, atmospheric processes, freshwater hydrology, and terrestrial-aquatic linkages combine to determine the security and resource base of coastal economies and peoples. NOAA is in a unique position to catalyze and support this synthesis and integration, albeit not necessarily with current internal R&D staff.

Although the Task Force did not have the resources to fully examine NOAA's current observing systems and how they should be evolved into the future, it became clear that several issues warrant a thoughtful review. ***(Recommendation 7) The PRTF recommends that the SAB form a special task force to review existing observing capabilities, examine options for more cost-effective observation and data sharing strategies, and discuss evolving needs and sustainable approaches for new observations and technologies.*** The following questions should be pursued as aspects of that assessment:

- What is the value of information gained from improvements to observing systems per dollar invested, taking into account the full range of users? And how can the operation and management of current future observing systems be changed to yield the greatest return on investment?
- Are there new technologies such as ground-based remote sensors, unmanned aerial and underwater systems, and robotic/smart sensing systems that could ultimately yield equivalent or better data at lower cost than current observing platforms?
- To what extent could the development, installation, and operation of observing systems be shared with private sector, university, and/or state government partners for lower cost and equivalent data quality?

Recommendations for Changes in the Organization and Management of R&D

To provide NOAA with the flexibility it needs to reorient its R&D to meet the requirements of the Next Generation Strategic Plan, the Task Force recommends that the agency make major changes in its organization and management of R&D. This is also critical to strengthening certain areas of research already ongoing at NOAA. The recommended changes involve (1) an administrative reorganization and the creation of a new leadership position for R&D in the agency; (2) consolidation of some R&D entities; (3) a reduction in the size of the permanent scientific staff at the agency while retaining a core internal staff of exceptional quality; (4) expansion in external collaborations and increased leveraging of R&D conducted outside NOAA; and (5) an expanded focus on fostering creativity and excellence in interdisciplinary research by NOAA scientists.

The Task Force recommends that work toward these changes begin immediately, recognizing that they will take time to implement. The recommended timing for full implementation of these changes is September 30, 2015.

Recommendations for New Leadership

In its 2004 report on research, the NOAA Science Advisory Board recommended that an Associate Administrator for Research be appointed who reported to the Administrator. They recommended that this person chair the Research Board, which was to be made up of members of the NOAA Executive Council, that is, the NOAA leadership and Assistant Administrators (AAs). They also recommended establishing a Research Council, made up of senior research officials from each line office and headed by the AA for OAR, to serve as an implementing and information gathering arm of the Research Board.[1]

The NOAA response to the 2004 recommendations was too limited to be effective. This was especially true in regard to leadership. The position of Chief Scientist was not filled at that time and currently is filled by an appointment in an acting capacity with an incumbent who does not have budget authority over R&D. Moreover, although the Research Council was formed on the recommendation of the SAB, most of its attention has been focused on administrative matters rather than on research initiation, direction, and evaluation.

As a result of its review, the PRTF finds that leadership of NOAA research is weak and fragmented. It agrees with the earlier recommendations of the 2004 SAB report, but believes that the situation warrants an even stronger, more centralized approach to the direction and management of NOAA R&D.

(Recommendation 8) The Task Force recommends that the current Chief Scientist position be replaced by a Deputy Undersecretary of Commerce for R&D. The incumbent in this position should have both line and budget responsibility for R&D and responsibility for the functions currently organized under the OAR, research functions in other line offices, and the Research Council.

The recommended Deputy Undersecretary of Commerce for R&D will have responsibility for balancing the distribution of existing scientific expertise to meet the requirements of the NGSP and planning and developing new and expanded scientific expertise in the socioeconomic sciences, the ecosystem sciences, and integrated observing systems. The incumbent shall also be accountable for ensuring that NOAA has the research and development capabilities it needs to implement the Next Generation Strategic Plan.

Consolidation of R&D Entities at NOAA

(Recommendation 9) NOAA must retain a strong, productive internal scientific staff in its laboratories and centers. However, ***(Recommendation 10), NOAA's many research units and groups should be consolidated to the maximum extent possible, and duplicative or low – priority enterprises eliminated.***

Extant R&D efforts should be consolidated and some labs should be eliminated in order to cut costs so that resources can be freed up for more effectively transitioning research to operations and for

[1] NOAA Science Advisory Board, "Review of the Organization and Management of Research in NOAA", 2004, p.13

initiating new research activities. For example, one area that should be examined for potential administrative consolidation is the work being done in OAR and in the fisheries labs and other facilities, which could be consolidated into a single research entity. The new, consolidated R&D units should be held accountable for the relationship of R&D to service, operations, and stewardship activities within NOAA.

(Recommendation 11) NOAA should reexamine the Cooperative Institutes in terms of their scientific focus and funding and staffing levels to insure that the CIs have sufficient support to adequately leverage NOAA's investment. This will likely mean closing some CIs and shifting the savings to the highest priority CIs as judged by their alignment with strategic priorities. The Cooperative Institutes are a valuable part of the NOAA portfolio. They provide the agency with access to younger scientists and post-doctoral fellows in the universities and contribute to the agility and flexibility of the total R&D portfolio. However, NOAA's current investment in CIs is inadequate for the number of Institutes being supported. Interviews with CI representatives revealed that budget reductions were undermining the original intent of these CI's to leverage NOAA's resources. This suggests that, valuable as the CIs are to NOAA, the agency should reexamine and adjust the total number of CIs so that it can provide adequate levels of support to those CIs that are retained and will allow them to function efficiently and effectively.

Changes in the Size of the Scientific Staff

(Recommendation 12) In order to initiate new types of research and consolidate existing research, NOAA should alter its distribution of R&D funds and allocation of scientific staff within the agency. Three avenues of change are needed: 1) there must be mechanism for stopping and redirecting the funding of existing research efforts that do not address the highest priorities as expressed in the Next Generation Strategic Plan or are redundant with other efforts within NOAA or within the external research community; 2) there should be increased reliance on extramural research because the extramural workforce can be more flexible than a permanent in-house scientific workforce; and 3) there should be incentives for building or hiring new research skills and expertise within NOAA.

With limited budgets, funds for new scientific initiatives can only come with either 1) reducing some current staff positions, or 2) cutting extramural programs. The task force concludes that reallocation of funds that rely only on extramural cuts would greatly interfere with NOAA's ability to meet its mission. Hence ***(Recommendation 13) the PRTF recommends some cuts in existing scientific or staff positions (or both) so that resources supporting current in-house and extramural scientific capacity can be reallocated to emerging priorities such as social science, ecosystem science, and observing systems.***

The first step in reducing the size of current R&D staff should be through reassignment. For example, if NOAA's science planning effort is simplified and consolidated under a new Undersecretary**,** this could free some scientists currently engaged in planning and management to devote greater time to their research. The second step is to reduce the total R&D staff through attrition and protecting those now-vacant positions for new hires in different fields and locations. The third step is to acquire additional funds and FTE's by offering retirement incentives to current

scientists. The fourth step, if necessary and in consultation with Congress, is to initiate a reduction in force (RIF) process. The process of reducing the scientific staff of the agency should be undertaken not because of inadequacies in the current staff but in order to obtain funds for scientific expansion in new areas of strategic and scientific priority and for collaborations with other science agencies and extramural scientists. This process will not be easy; nor will it be fast. It is likely to take 5-10 years to complete in full and it will have to be carefully managed by NOAA leadership. Yet despite the difficulties, the Task Force believes that this is the only way to alter and reorient the scientific profile of NOAA's R&D staff and make the significant changes in the NOAA R&D portfolio that are required over the next decade.

It is essential that these steps be undertaken with the full support of the Department of Commerce, OMB, and the Congress, and that if NOAA takes the unprecedented steps leading to reductions in current scientific and other staff, it not be penalized by losing either the FTE's or the funding that the agency saved in order to redirect its scientific activities.

External Collaborations and Leveraging

It is critical that the NOAA's research portfolio be appropriately balanced between internal research and extramural research; at the present time, it is too heavily weighted toward internal R&D. ***(Recommendation 14) NOAA should increase its support of extramural research.*** Increased extramural research could allow NOAA to leverage its R&D investment with the resources of the nation's leading university scientists. It could obtain greater and faster scientific advances at lower costs, particularly in new areas of research. This pathway would also provide NOAA with greater flexibility, as permanent staff need not always be hired to conduct the research. To some extent, increasing NOAA's investment in extramural research can also compensate for NOAA's aging workforce.

At the same time, a strong internal R&D capability aligned with NOAA's strategic priorities is essential to maintain continuity and support longer term investments than are typical for extramural efforts. Moreover, NOAA scientists have a reward system that emphasizes research outcomes that are easily translated into improved operations, whereas extramural scientists operate under a more academic publish-or-perish reward system in which novelty and theoretical significance is what is most valued.

The balance between extramural and internal research will vary among different NOAA research activities and over time, but a predictable and reliable partnership with the extramural research community is critical to NOAA's long-term success. The Deputy Under Secretary for Research should be responsible for overseeing the strategic balance between extramural and internal research, and for doing so in accord with the service mission of NOAA. The accountability and authority for this should stem from budget authority and the ability to direct research resources in a manner that best accomplishes NOAA's mission viewed from the "whole NOAA" perspective, as opposed to line office by line office.

External scientists working with NOAA should be treated like the valuable partners they are. Task Force interviews with individuals in the extramural research community revealed some frustration

because of a sense that as the NOAA budget got squeezed, the first things to be cut were extramural programs or collaborations with other science agencies. This leads to widespread uncertainty in the scientific community about NOAA's commitment to research and to poor relations with other agencies and the university research community. It also eliminates the economic and scientific benefits of some very highly leveraged investments.

Fostering Creativity and Excellence in Interdisciplinary Research

(Recommendation 15) In the current Federal budget situation, it is imperative NOAA makes the most of its existing talent and finds ways to accelerate learning and professional development of that talent. Scientists within NOAA need to have a clear science career path available to them that keeps them invigorated and productive scientists and which does not require that they move into administration as they become more senior. More extensive use of Scientific or Professional (ST) or SL (Senior Level) positions under the Senior Executive Service would provide a means of advancement for scientists that does not require them to take on extensive supervisory or management responsibilities.

Interviews with PECASE (Presidential Early Career Award for Scientists and Engineers) winners and the Internet survey responses revealed several relatively low-cost avenues by which this could be done, as identified by the bench scientists themselves. First, interactions with universities and external scientists were seen as critical to maintaining cutting edge science, and the NOAA bench scientists who were most energized and enthusiastic about their research output tended to mention being associated with extramural scientists. Vigorous interchanges among academic scientists and NOAA scientists enhance NOAA creativity. A modest amount of discretionary funding that could be used to create incentives for interdisciplinary research and research across line offices would be beneficial. Working groups and perhaps a virtual center such as the National Center for Ecological Analysis and Synthesis (NCEAS) could yield major advances without requiring large additions in the number of staff. Attendance at leading national and international science meetings is necessary for scientists to build networks and become aware of new developments elsewhere. The travel restrictions the federal government has adopted cuts its scientists off from the rest of the world in ways that could seriously hinder NOAA's ability to meet its service mission in the medium and long term. With the USA lagging in science, technology, and math education, NOAA cannot afford to fence its scientists off from the global community of scientists. Lastly, while leveraging university science is something NOAA leadership appreciates and pursues, there is merit in also pursuing partnerships with other Federal science agencies and with private (non-profit or corporate) science. Businesses that depend on ocean resources and non-profits whose missions embrace marine sustainability are natural allies for NOAA science.

The Political Context within which NOAA Operates

Implementing priorities for research and development at NOAA is not a straightforward process. Identifying scientific priorities within the agency is merely the first step in a multiyear process of budgeting which is shaped by numerous external, administrative, and political influences. Heretofore, the process has been governed more by political necessity (and internal parochial interests) than by overall agency scientific priorities.

Funding for all NOAA R&D, including both new and ongoing research priorities must be approved each year, and even long term R&D priorities such as those identified in the Next Generation Strategic Plan must be budgeted anew every year. This requirement inevitably introduces uncertainty into scientific priority setting. For example, before the annual NOAA budget is sent to Congress, it has to be approved by the Department of Commerce and the Office of Management and Budget. Then, when it is approved in the Administrative Branch of government, the budget is submitted to the Legislative Branch. Ultimately, Congress must approve the final budget for the agency and does so in the context of multiple legislative, regional, and financial priorities.

Although this sounds complicated, it is an integral part of the separation of powers in the American governance process. In principle, it is through the federal budget process that elected representatives of citizens of the United States review and ultimately approve government spending plans and this responsibility should not (and will not) be abrogated. In practice, however, the lengthy annual budget process, combined with a tradition of examining NOAA spending at the programmatic level and Congressional protection of regional and local interests, is inefficient, dysfunctional from a scientific perspective, and often militates both against Congress' desire to make effective budget decisions and against NOAA's ability to implement its priority decisions about R&D spending.

Given the way that the budgeting and appropriations process is currently organized, there appears to be little flexibility for NOAA to change its R&D activities in order to implement the NGSP priorities across and within programs.[2] ***(Recommendation 16)The Task Force recommends that NOAA work closely with the Department of Commerce Department, the Office of Management and Budget, and with the Congress to find ways to manage its R&D funds more flexibly and efficiently and to implement its new research priorities over a period of several years.*** In particular, ***(Recommendation 17) it will be essential to have an R&D firewall in place to protect NOAA's R&D funding as the agency systematically goes through the changes recommended in this report.*** Such a firewall must also be negotiated by NOAA with the Department of Commerce, the Office of Management and Budget, and Congress in advance of implementing the changes.

The difficulties in managing NOAA's R&D funds are compounded by continuing earmarks and reprogramming restrictions. One of the factors that limit NOAA's R&D flexibility is its inability to redirect internal funding to adjust its R&D portfolio to respond to changing needs and shifting scientific priorities. NOAA's appropriation currently limits any changes to $500,000 or 10% of the budget (whichever is less) of a Congressionally-recognized program, project, or activity before approval of Congress must be sought. However, when research funding is divided into multiple

[2] Consolidated and Further Continuing Appropriations Act, 2012; General Provisions of the Commerce, Justice, Science Appropriations, Section 505.

small programs, projects, or activities, NOAA has very limited flexibility to redirect funding to higher priority activities. Again, if NOAA undertakes to reduce its internal R&D staff in order to change the distribution between intramural and extramural research and to diversify the disciplinary distribution of its R&D, it must be able to protect the funds it saves in order to use them for their intended purposes.

Because of the legitimate interests of the Congress and the Administration in NOAA's mission and programs, it will be essential for NOAA to work closely with both in reorienting its R&D activities under the Next Generation Strategic Plan and creating the management and organizational structure required to do this most effectively.

Conclusions: A Suite of Recommendations so that NOAA Does Not Dissipate its Strengths in an Era of Tight Budgets

In spite of considerable challenges, NOAA remains a global science leader in atmospheric and ocean systems, and especially in translating science to service and stewardship. In order to maintain this position, the Task Force arrived at seventeen specific actions that were numbered and highlighted throughout the report.

1) *The PRTF recommends that NOAA develop a strong capacity in the socioeconomic and integrated ecosystem sciences and reinforce its emphasis on operations and integrated observing systems so that new knowledge can be rapidly used to benefit the nation*.
2) *The PRTF recommends that funding be reallocated from R&D in other fields of science at NOAA in order to build both an in-house capacity in the socioeconomic sciences and extramural capacity in these fields.*
3) *The PRTF recommends NOAA both bolsters and concentrate its ecosystem science activities to establish the critical research capacity it needs in integrated ecosystem sciences.*
4) *The PRTF recommends that NOAA place greater emphasis on connecting research and operations in both the research to operations (R2O) direction and the operations to research (O2R) direction.*
5) *The PRTF recommends that as a way of enhancing the transitioning of research into operations/applications, NOAA forge new partnerships of researchers and end-users at the outset of projects, and to continue these partnerships until the project is complete. This also applies to partnerships among NOAA personnel and university and NGO researchers through extramural programs.*
6) *The PRTF recommends that NOAA makes effectiveness in transitioning research to operations an explicit metric in annual performance evaluations of all NOAA scientists, laboratory and center administrators, and other relevant personnel.*
7) *The PRTF recommends that the SAB form a special task force to review existing observing capabilities, examine options for more cost-effective observation and data sharing strategies, and discuss evolving needs and sustainable approaches for new observations and technologies.*

8) *The PRTF recommends that the current Chief Scientist position be replaced by a Deputy Undersecretary of Commerce for R&D. The incumbent in this position should have both line and budget responsibility for R&D and responsibility for the functions currently organized under the OAR, research functions in other line offices, and the Research Council.*

9) *The PRTF recommends that NOAA retain a strong, productive internal scientific staff in its laboratories and centers.*

10) *The PRTF recommends that concomitant with maintaining a strong internal science staff, NOAA's many research units and groups should be consolidated to the maximum extent possible, and duplicative or low –priority enterprises eliminated.*

11) *The PRTF recommends that NOAA reexamine the Cooperative Institutes in terms of their scientific focus and funding and staffing levels to insure that the CIs have sufficient support to adequately leverage NOAA's investment. This will likely mean closing some CIs and shifting the savings to the highest priority CIs as judged by alignment with strategic priorities.*

12) *The PRTF recommends that in order to initiate high priority new research and consolidate existing research, NOAA should alter its distribution of R&D funds and allocation of scientific staff within the agency.*

13) *The PRTF recommends some cuts in existing scientific or staff positions (or both) so that resources supporting current in-house and extramural scientific capacity can be reallocated to emerging priorities such as social science, ecosystem science, and observing systems.*

14) *The PRTF recommends that NOAA increase its support of extramural research.*

15) *The PRTF recommends that NOAA make the most of its existing talent by investing in programs for accelerated learning and professional development for its science staff.*

16) *The PRTF recommends that NOAA work closely with the Department of Commerce Department, the Office of Management and Budget, and with the Congress to find ways to manage its R&D funds more flexibly and efficiently and to implement its new research priorities over a period of several years.*

17) *The PRTF recommends that NOAA establish an R&D firewall so that as the agency systematically goes through the changes recommended in this report, R&D funding is protected.*

The bottom line for NOAA R&D is that business as usual is not an option. Profound changes are needed to meet the emerging challenges facing the nation with regard to ocean resources and climate and weather disruptions. Either NOAA makes thoughtful internal changes to sharpen its R&D focus, or else external factors will force, rapid, likely ill-conceived changes on the agency.

The above recommendations need not all be adopted at once, but a few stand out as highest priorities: new top-level leadership position with budgetary authority, investment in social science and ecosystem science, retaining a core scientific capability while consolidating institutions and centers, reduction in staff to accommodate increased investment in new areas, increasing and leveraging research by academic and government partners, and working with Congress and

OMB to streamline and make more transparent the link between budgeting and NOAA's mission-oriented priorities.

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Appendices

Appendix I: Portfolio Review Task Force: Terms of Reference

Charge

The Science Advisory Board will conduct a needs-based review to provide advice to NOAA on prioritization of the agency's research and development (R&D) portfolio (including identification of gaps and areas for integration of effort) that is strongly linked to NOAA's current Strategic Plan and recognizes the high likelihood of constrained financial resources. Further, the SAB will provide advice on an appropriate organizational approach within NOAA for support of this R&D portfolio.

The intended audience for this review is NOAA leadership, Department of Commerce leadership, the Office of Management and Budget, the Office of Science and Technology Policy, as well as the US Congress.

Questions

A successful review of NOAA's R&D portfolio is one that provides clear answers to NOAA leadership, staff, and policy makers in Congress for the following questions, as posed by the NOAA Administrator:

1. What portfolio of R&D activities does NOAA need to achieve its vision and strategic goals?
    - What R&D portfolio does it currently have?
    - What are the differences?
    - What changes should be made?
    - What changes take priority?

2. How should NOAA's R&D portfolio be organized and managed to achieve its vision and strategic goals? Is NOAA's expertise appropriate?
    - How is it organized and managed now? What expertise does it have now?
    - What are the differences?
    - What changes should be made?
    - What changes take priority?

Assumptions

- By managing R&D as a portfolio, NOAA can explicitly assess the tradeoffs among competing investment opportunities in terms of their benefits, costs, and risks.
- A business model for R&D based on agency strategy yields a business case for OMB, Congress. The results of this portfolio review may be used as a basis for advocacy for NOAA R&D.
- This review will take a "zero-based" rather than an incremental approach to strategy, but recognize limits to change.
- This review will stay at the strategic level, sacrificing depth for breadth.
- NOAA's research can be directed toward fundamental understanding ("pure basic research") ultimate use ("pure applied research"), or both ("use-inspired research").

Scope

The scope of this study includes NOAA's research and development portfolio. Research and development at NOAA is defined consistent with the definitions used by the National Science Foundation (http://www.nsf.gov/statistics/nsf10303/pdf/nsf10303.pdf, pages 337-338) and the Office of Management and Budget (http://www.whitehouse.gov/sites/default/files/omb/circulars/a11/current_year/s84.pdf,

pages 7-8).

The organizational scope of the study includes all of NOAA's R&D activities as well as the R&D activities of external partners that are conducted with NOAA support. It should also consider the transfer of knowledge and technology that results from R&D to its intended application. The study may consider other key activities and infrastructure as necessary to answer the questions above.

The task force will provide enough detail in its recommendations to identify where changes should be made and where new opportunities exist and to inform budget prioritization or organizational changes.

Timing

Preliminary recommendations for both questions will be provided to NOAA by the middle of November 2012, including a high level identification of opportunities and issues for both the composition of NOAA's R&D portfolio and its organization/management, with emphasis on the former. The final report will be provided to the SAB at its Spring 2013 meeting.

Roles and Responsibilities

PRTF members will contribute to the development of analysis frameworks, determine information required by NOAA, meet with relevant parties, analyze information, and develop recommendations. The PRTF will have two co-chairs who will coordinate activities within the PRTF, with the SAB, and with NOAA. The co-chairs will also deliver preliminary and final reports to the SAB.

NOAA will work with the PRTF to develop approaches to provide the information required; deliver information about NOAA's requirements, NOAA's R&D enterprise, and the infrastructure that supports R&D. NOAA will also provide logistical support for preparing PRTF materials, travel, and meetings. NOAA will cover the PRTF-related travel expenses for task force members.

Appendix II: Members of the Task Force

Co-Chairs
Roberta Balstad, Special Research Scientist, Columbia University
Peter Kareiva, Chief Scientist, The Nature Conservancy (SAB Member)

Members
Susan Avery, President, Woods Hole Oceanographic Institution (SAB Member)
Lesley-Ann Dupigny-Giroux, Associate Professor of Geography, University of Vermont; VT State Climatologist
Frank Kudrna, Principal Water Resource Engineer, URS Corporation, Chicago
Berrien Moore, Dean, University of Oklahoma College of Atmospheric & Geographic Sciences
James Neil Sanchirico, Professor, University of California, Davis (SAB Member)
Jerry Schubel, President and CEO, Aquarium of the Pacific (SAB Member)
John Snow, Regents Professor of Meteorology, University of Oklahoma

Ex-Officio
Ray Ban, Ban and Associates and Chair, SAB

Appendix III: List of Meetings and Teleconferences

January 5, 2012-Teleconference Meeting

January 27, 2012-Teleconference Meeting

February 21-22, 2012-Meeting in Silver Spring, Md.

March 14, 2012-Teleconference Meeting

April 4, 2012-Meeting in Washington, D.C.

May 16-17, 2012-Meeting in Silver Spring, Md.

July 17-18, 2012-Meeting in Seattle, Wa.

September 5-6, 2012-Meeting in Boulder, Co.

October 4, 2012-Teleconference Meeting

Appendix IV: List of individuals and groups interviewed by Task Force and SAB Working Groups and NOAA Federal Advisory Committees providing comments

Research and Development Portfolio Review Task Force (PRTF)

Interviews, Meetings, and Comments from SAB Working Groups and NOAA Federal Advisory Committees and Number of People involved

(as of October 1, 2012)

Ocean Leadership-(2)

National Ocean Service(8)

National Weather Service/National Environmental Satellite Data and Information Service (4)

Office of Oceanic and Atmospheric Research, Senior Research Council (17)

National Marine Fisheries Science Centers (11)

Assistant Administrators or Designees (6)

NOAA Council of Fellows (7)

Cooperative Institutes Executive Council (4)

NOAA Presidential Early Career Awards in Science And Technology (PECASE) Winners(6)

NOAA Social Scientists (4)

Former NOAA Administrators (3)

National Center for Atmospheric Research/University Corporation for Atmospheric Research (2)

Other Meetings—Number of People Involved Unavailable

Office of Management and Budget

Meetings with Staff from the following Congressional Committees: House Committee on Appropriations, Subcommittee on Commerce, Justice and Science ; Senate Commerce, House Committee on Science, Space and Technology; and House Committee on Natural Resources.

Subtotal- People Involved in Meetings and Interviews 74 (without numbers for Congressional and OMB meetings)

Working Groups and number of members (including SAB liaisons)

Ecosystem Sciences and Management Working Group -13

Environmental Information Services Working Group-15

Data Archiving and Access Requirements Working Group-11

Climate Working Group-18

Federal Advisory Committees

The Marine Fisheries Advisory Committee (MAFAC) (1-individual comment)

Marine Protected Areas Federal Advisory Committee(MPAFAC) (1-individual comment)

Hydrographic Services Review Panel (HSRP) (18 members)

Subtotal-Number of Working Group Members, Federal Advisory Committees--77

Appendix V: Overview of the NOAA Next Generation Strategic Plan

(Excerpted from NOAA's Next-Generation Strategic Plan)

NOAA's Mission: Science, Service, and Stewardship

- *To understand and predict changes in climate, weather, oceans, and coasts,*
- *To share that knowledge and information with others, and*
- *To conserve and manage coastal and marine ecosystems and resources.*

NOAA's Vision of the Future: Resilient Ecosystems, Communities, and Economies

- *Healthy ecosystems, communities, and economies that are resilient in the face of change*

  Resilient ecosystems, communities, and economies can maintain and improve their health and vitality over time by anticipating, absorbing, and diffusing change. This vision of resilience will guide NOAA and its partners in a collective effort to reduce the vulnerability of communities and ecological systems in the short-term, while helping society avoid or adapt to long-term environmental, social, and economic changes. To this end, NOAA will focus on four long-term outcomes within its primary mission domains.

NOAA's Long-term Goals:

Climate Adaptation and Mitigation

- *An informed society anticipating and responding to climate and its impacts*

  Objective: *Improved scientific understanding of the changing climate system and its impacts*
  Objective: *Assessments of current and future states of the climate system that identify potential impacts and inform science, service, and stewardship decisions*
  Objective: *Mitigation and adaptation choices supported by sustained, reliable, and timely climate services*
  Objective: *A climate-literate public that understands its vulnerabilities to a changing climate and makes informed decisions*

Weather-Ready Nation

- *Society is prepared for and responds to weather-related events*

  Objective: *Reduced loss of life, property, and disruption from high-impact events*
  Objective: *Improved freshwater resource management*
  Objective: *Improved transportation efficiency and safety*

Objective: *Healthy people and communities due to improved air and water quality services*
Objective: *A more productive and efficient economy through environmental information relevant to key sectors of the U.S. economy*

Healthy Oceans

- *Marine fisheries, habitats, and biodiversity are sustained within healthy and productive ecosystems*

Objective: *Improved understanding of ecosystems to inform resource management decisions*
Objective: *Recovered and healthy marine and coastal species*
Objective: *Healthy habitats that sustain resilient and thriving marine resources and communities*
Objective: *Sustainable fisheries and safe seafood for healthy populations and vibrant communities*

Resilient Coastal Communities and Economies

- *Coastal and Great Lakes communities are environmentally and economically sustainable*

Objective: *Resilient coastal communities that can adapt to the impacts of hazards and climate change*
Objective: *Comprehensive ocean and coastal planning and management*
Objective: *Improved coastal water quality supporting human health and coastal ecosystem services*
Objective: *Safe, efficient and environmentally sound marine transportation*
Objective: *Safe, environmentally sound Arctic access and resource management*

NOAA's S&T Enterprise Objectives:

- *A holistic understanding of the Earth system through research*
- *Accurate and reliable data from sustained and integrated Earth observing systems*
- *An integrated environmental modeling system*

Overarching, long-term scientific and technical challenge to NOAA:

To develop and apply holistic, integrated Earth system approaches to understand the processes that connect changes in the atmosphere, ocean, space, land surface, and cryosphere with ecosystems, organisms, and humans over different scales.

Over the long-term, drawing upon its world-class research, observation, and modeling capabilities, NOAA is uniquely positioned to:

- *Acquire and incorporate knowledge of human behavior to enhance understanding of the interaction between human activities and the Earth system;*
- *Understand and quantify the interactions between atmospheric composition and climate variations and change;*
- *Understand and characterize the role of the oceans in climate change, and variability and the effects of climate change on the ocean and coasts;*
- *Assess and understand the roles of ecosystem processes and biodiversity in sustaining ecosystem services;*
- *Improve understanding and predictions of the water cycle from global to local scales;*
- *Develop and evaluate approaches to substantially reduce environmental degradation;*
- *Sustain and enhance atmosphere-ocean-land-biology and human observing systems;*
- *Characterize the uncertainties associated with scientific information; and*
- *Communicate scientific information and its associated uncertainties accurately and effectively to policy makers, the media, and the public at large.*

Appendix VI: Results of the PRTF Web Survey of Bench Scientists

Appendix VII: The Socioeconomic Sciences at NOAA

Over the last ten years, two ad-hoc working groups of the SAB have provided guidance for NOAA on social science research. The two reports, which predated the Next Generation Strategic Plan, advocated that NOAA increase its investment in this area[3] and highlighted how socioeconomic scientists can help to improve the planning and budgeting process as well as NOAA's ability to meet its mission.

Given the goals, objectives, and metrics of the NGSP, the task force sees an even more pressing need for quantitative social science research at NOAA than existed at the time the previous SAB reports were written. Unfortunately, the trend has been in the wrong direction. In 2011, Dr. Jane Lubchenco, who strongly supports increased investment in the social sciences, commented that "the social sciences continue to account for a miniscule fraction of NOAA's overall budget—just 0.6% in 2008. Between 2005 and 2008, both budgetary and staff support for social science have weakened."[1] The implication is that NOAA has further to go in advancing social science research to meet its NGSP goals than ever before.

Socioeconomic Research Required by the NGSP

Goal	Objective
CAM	Mitigation and adaptation choices supported by sustained, reliable, and timely climate services
CAM	A climate-literate public that understands its vulnerabilities to a changing climate and makes informed decisions
WRN	Healthy people and communities due to improved air and water quality services
WRN	Improved freshwater resource management
WRN	Reduced loss of life, property, and disruption from high-impact events
RCCE	Resilient coastal communities that can adapt to the impacts of hazards and climate change
RCCE	Comprehensive ocean and coastal planning and management
RCCE	Improved coastal water quality supporting human health and coastal ecosystem services
HO	Sustainable fisheries and safe seafood for healthy populations and vibrant communities
HO	Healthy habitats that sustain resilient and thriving marine resources and communities

In the Table, we group a subset of the objectives from the NGSP plan that require similar types of social science expertise and could form the basis of "new" investments in coupled natural-human dimensions research. These new investments could be coupled with new critical research areas, such as ocean acidification, or help to improve aspects of NOAA's traditional research enterprise,

[3] "Social Science Research Within NOAA: Review and Recommendations", March, 2003; and "Integrating Social Science into NOAA Planning, Evaluation and Decision Making: A Review of Implementation to Date and Recommendations for Improving Effectiveness", April 2009. Both reports and the NOAA response can be found at www.sab.noaa.gov/Reports/Reports.html

such as weather and ocean forecasts. With respect to ocean acidification, one respondent in our survey commented that:

"Ocean acidification is a relatively new field, and therefore, there are many opportunities for new research. … There is a need to fund research at the intersection of carbon chemistry, organism response, ecology, modeling, etc, and then interpret and synthesize that information into products targeted for federal, tribal, state, and local governments, industry leaders, resource managers, policy mangers and the public …" This research effort should also include social scientists and economists that can integrate human dimension activities. There is currently a need, which will likely increase in the future, to make decisions about CO2 emission reductions, how to manage multiple stressors to marine ecosystems, how to prepare communities for ecosystem changes, etc. Making these decisions will require consideration of ecological predictions, the value of ecosystem services, and the economic and social costs of proposed actions."

The objectives of Weather-Ready Nation (WRN) are based on the combination of improving the science of forecasts and the use and incorporation of that information into decision-making. While improvements in lead-time and path have an important role to play in safety and reducing damages of extreme weather events, other key factors are the diffusion of information (e.g., via social networks) and land-use and transportation planning. Understand the spatial-dynamics of the human dimensions of these issues falls in the realm of social science. One respondent of our survey commented that social science research on how people interpret and respond to weather watch and warning messages could make a significant difference to NOAA.

Appendix VIII: Summary of Information Provided by NOAA to the Task Force

To support its review, the task force requested a wide variety of information from NOAA about its research and development (R&D) enterprise. Given the nature of the task force's charge and the importance of receiving information quickly, the task force agreed that providing numerical information that was accurate to within ±10% was generally acceptable. NOAA also provided additional information that it thought would assist the task force. The information that NOAA provided the task force is listed below.

The term "R&D unit" refers to a NOAA organization that supports and/or conducts significant R&D (e.g., a laboratory, science center, granting program).

Description	Approach Used to Collect/Summarize Information
A count of "bench scientists" by organization, scientific area, and type of employer	Since the term "bench scientist" is vague and might not cover all of the people conducting R&D, the task force and NOAA agreed that NOAA would count people working at a NOAA facility, whether or not the person is a federal employee, who are encouraged or expected to publish peer-reviewed technical reports, journal articles, or other peer-reviewed materials--even if those people would not be a lead author. Each NOAA R&D unit leader had the option to include additional employees whose scientific work is integral to the scientific research of the unit and/or who facilitate and enable peer-reviewed publications but may not necessarily appear as co-authors on the papers. Most line offices asked R&D unit leaders to provide this information. The National Marine Fisheries Service provided this information for its Federal scientists by using job series and grade criteria, which probably significantly overestimated the number of scientists.
Survey NOAA "bench scientists" and ask about what work they find exciting, future opportunities, and their work environment	NOAA conducted a web-based survey.
Nine examples of NOAA R&D improving products and services	Line offices submitted more than two dozen ideas. The best eleven were selected based on the importance of the improvements and representation of the breadth of NOAA's R&D activities.
Research that is being done by other agencies that is critical to NOAA operations and/or research	Line offices provided a list of research activities upon which they critically depend
The names of NOAA's STs (senior scientists) and when they were appointed	Information was collected from the STs.

NOAA's R&D priorities and how they relate to NOAA Next-Generation Strategic Plan (NGSP) objectives	R&D priorities were extracted from a NOAA-wide planning document that listed high-level priorities. Some additional priorities were identified in NOAA internal implementation plans and other documents. These priorities were organized by NGSP objective.
NOAA's R&D needs	Needs were extracted from NOAA internal implementation plans.
R&D programs that were proposed to be reduced or eliminated in the fiscal year (FY) 2013 budget	Information was extracted from the FY 2013 President's Budget
Key direct stakeholder groups for NOAA R&D	Line offices and mission goals identified broad stakeholder categories (e.g., industry, academia) and some key examples within each category.
Information about FY 2011 R&D solicitations	Summary information was provided by line offices.
NOAA Administrative Orders on scientific integrity, strengthening science, and transitioning research to applications	These documents were provided.
Summaries of NOAA science challenge workshops	These documents were provided.
History of NOAA	Provided a NOAA history from the NOAA web site.
Dr. Lubchenco's budget roll-out for constituents	Dr. Lubchenco's slides were provided.
Provide total and R&D funding for each of NOAA's R&D units	Information was extracted from NOAA's financial databases for FY 2011.
Categories of R&D that NOAA conducts	Representatives from line offices and mission goals developed a categorization of NOAA's R&D.
Changes in research emphasis and investment that have been made as a result of the NGSP	Representatives from line offices and mission goals described the impact of the NGSP on R&D.
Description of NOAA's long-term keystone external grant/cooperative agreement-based partnerships	Information was provided by line offices.
How NOAA's R&D units support the NGSP	NOAA provided a table showing those connections.
Scientific areas for new STs	Information was extracted from job descriptions and postings.
How NOAA develops R&D priorities	Representatives from line offices and mission described the relevant planning processes.
NOAA's new guidance on conducting R&D evaluations	The evaluation chapter of the handbook that describes the implementation of the NOAA Administration Order on Strengthening NOAA's Research and Development Enterprise was provided.
Examples of how the new evaluation guidance has been applied	Line offices provided examples.
10-year history of intramural and extramural R&D funding	Information was extracted from NOAA records and anomalies that would affect interpretation of the time series were addressed.
R&D funding by mission goal	An approximate estimate was provided by categorizing line office and R&D unit funding.

NOAA Research Council terms of reference and list of agenda topics	The terms of reference and list of agenda topics for October 2010 through April 2012 were provided.
Position description for NOAA Chief Scientist	The description in the Department of Commerce Organization Order for NOAA was provided.
An example of an implementation plan	The implementation plan for the "holistic understanding of the Earth system through research" enterprise objective was provided.
Information about the formation of the Hurricane Forecast Improvement Project (HFIP)	Several documents were provided: background information, HFIP proposal for the NOAA Executive Council, language from the FY 2009 President's Budget highlights, and interim HFIP accomplishments.
Description of the Coastal Ocean Program	The National Ocean Service (NOS) provided a description.
Example of a NOAA annual operating plan (AOP)	The Oceanic and Atmospheric Research (OAR) AOP was provided.
Analyses of survey results	Staff supporting the task force provided summaries of the survey results.
Pointer to tool for visualizing sea level rise	NOS provided the link.
Information about the aging R&D workforce	NOAA extracted retirement eligibility information from its personnel databases for line offices and job series where a majority of the people are "bench scientists."
Information about the costs of performing intramural and extramural research	NOAA provided a summary of the overhead costs that one line offices charges another and of indirect costs for cooperative institutes and a sample of grantees.
Administration R&D priorities for FY 2014	The document prepared by the Office of Management and Budget and the Office of Science and Technology Policy was shared.
The R&D priorities of NOAA mission goals and enterprise science and technology (S&T) objectives	The leadership of each mission goal and S&T objective provided several R&D priorities.
Brief descriptions of R&D units	Line offices provided 1-2 page descriptions of R&D units.
Examples of how the OAR labs have worked together	OAR provided three examples of collaborative efforts addressing important societal challenges.
Provide information on the joint NSF-NOAA-supported Comparative Analysis of Marine Ecosystem Organization (CAMEO) program, including goals, decision process, and the use of NSF funds after the NSF-NOAA partnership ended	The National Marine Fisheries Service provided the requested information.
Information about other R&D agencies' budget structures	NOAA provided appropriations reports for several other agencies.
Line office total and R&D funding for FY 2010 and 2012	NOAA extracted the information from financial documents.
Reprogramming limits for NOAA and other agencies	NOAA provided Commerce-Justice-Science appropriations language describing reprogramming limits.

Appendix IX: List of NOAA staff who provided assistance to the Task Force